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MEASUREMENT OF BACK MOVEMENT

BY

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In population studies of a disease much valuable information is lost if, through lack of uniformity of diagnostic criteria and survey techniques, the results of one study cannot be directly compared with another. Two conferences (Kellgren, Jeffrey, and Ball, 1963; Bennett and Burch, 1967) have suggested diagnostic criteria for ankylosing spondylitis and these are shown in Tables I and II. Both sets of criteria specify limitation of movement of the lumbar spine presumably to be measured subjectively. We have recently undertaken a population survey of ankylosing spondylitis and it was felt that, in view of the problem of observer bias and changing standards of normality, an objective test of the motion of the lumbar spine should be developed and applied.

TABLE I
CRITERIA FOR THE DIAGNOSIS OF ANKYLOSING SPONDYLITIS (KELLGREN AND OTHERS, 1963)

Ankylosing Spondylitis Criteria (Rome)
1. Low back pain and stiffness > 3 months not relieved by rest
2. Pain and stiffness thoracic region
3. Limited motion lumbar spine
4. Limited chest expansion
5. History of iritis or sequelae
6. Bilateral sacroiliac changes on *x* ray characteristic of ankylosing spondylitis
Definite = four or five clinical criteria *or* Criterion 6 + one other

TABLE II
CRITERIA FOR THE DIAGNOSIS OF ANKYLOSING SPONDYLITIS (Bennett and Burch, 1967)

Ankylosing Spondylitis Criteria (New York)
1. History of pain in dorsolumbar spine and back
2. Limited motion lumbar spine, three planes
3. Chest expansion < 1 in. (4th inter-costal space)
4. Sacroiliitis on *x* ray
Definite = bilateral sacroiliitis radiographically (grade 3/4) + one other criterion
or unilateral sacroiliitis radiographically (grade 3/4)
or bilateral sacroiliitis radiographically (grade 2) + 1 or 2 and 3
Probable = bilateral sacroiliitis radiographically (grade 3/4)

We were attracted by a simple test of anterior flexion described by Schober (1937), which depended upon the stretching or distraction of the skin overlying the back on anterior flexion. The method was evaluated, modified, and applied to the population under survey.

Material and Methods

For the method of Schober (1937), the subject stood erect and the lumbosacral junction was identified and marked. Another skin mark was made 10 cm. above this. The subject then bent forward as far as possible and the distance between the marks was measured, the increase being a measure of anterior flexion. This method was modified by introducing a second measurement from the upper mark to a third mark placed 5 cm. below the lumbosacral junction, *i.e.* a distance of 15 cm. in the erect position. The accuracy of the two methods was checked radiologically by placing lead markers over skin marks on subjects with and without spinal disease and taking lateral radiographs with the subjects first standing erect and then in full anterior flexion. Care was taken to obtain true lateral films with sufficient bone detail. The distraction of the markers was measured directly and the inclination of the lumbar spine was estimated by measuring the angle formed by lines connecting the anterosuperior corner of the first lumbar vertebrae, the sacral promontory, and a convenient bony landmark on the sacrum, the same bony points having been identified to each pair of films by superimposition. Figs 1 to 4 (opposite) show the erect and flexed radiographs of two subjects.

Both tests were applied to the population under survey, comprising probands with ulcerative colitis, and their relatives and spouses, a total of 195 females and 147 males. The results were correlated with sex, age, and the clinical condition. In a selected group, height and weight were measured and their effect observed.

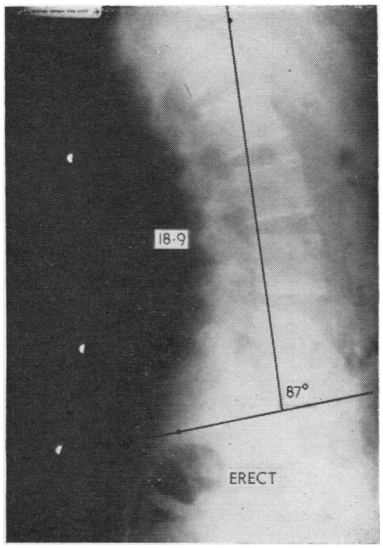

Fig. 1.—Radiograph of normal subject, erect, showing angulation of lumbar spine and skin markers.

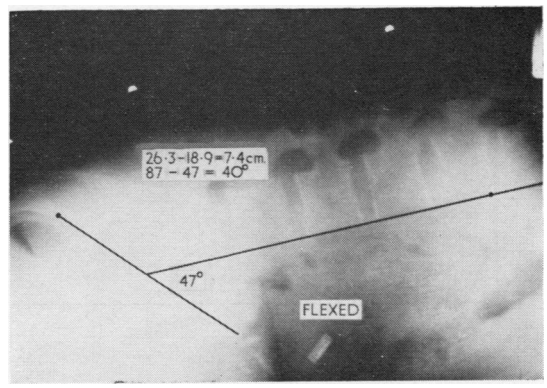

Fig. 2.—Radiograph of normal subject, flexed, showing angulation of lumbar spine and skin markers. There has been a distraction of the skin marks of 7·4 cm. and a decrease in the angle of 40°.

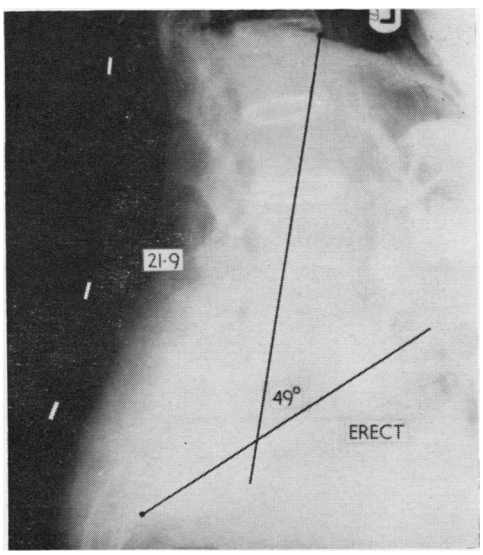

Fig. 3.—Radiograph of patient with Ankylosing Spondylitis, erect, showing angulation of lumbar spine and skin markers.

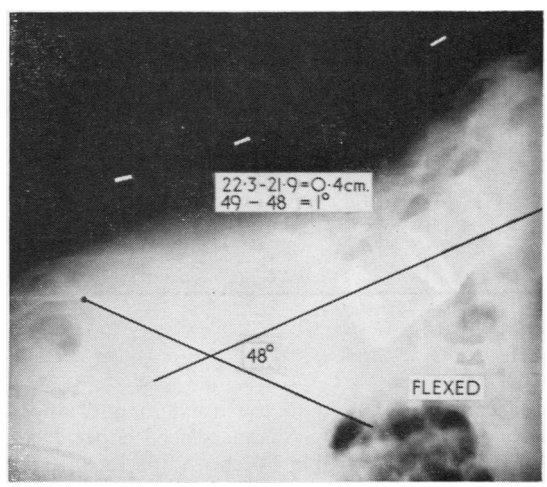

Fig. 4.—Radiograph of patient with Ankylosing Spondylitis, flexed, showing angulation of lumbar spine and skin markers. There has been virtually no distraction of skin markers and the angle has remained constant.

Results

The relationship between anterior flexion and skin distraction with Schober's method is shown in Fig. 5 (overleaf).

The correlation coefficient of 0·90 confirms the linear relationship and has a standard error of 6·2°. Fig. 6 (overleaf) shows the relationship with the modification we have introduced. The correlation coefficient of 0·97 indicates a very close conformity to a linear relationship and the standard error is smaller (3·25°).

Clinical identification of the lumbosacral junction was subject to an error of approximately 2 cm. when this was checked radiographically (Table III, overleaf). In order, therefore, to ascertain whether this interfered with the accuracy of the test, a number of

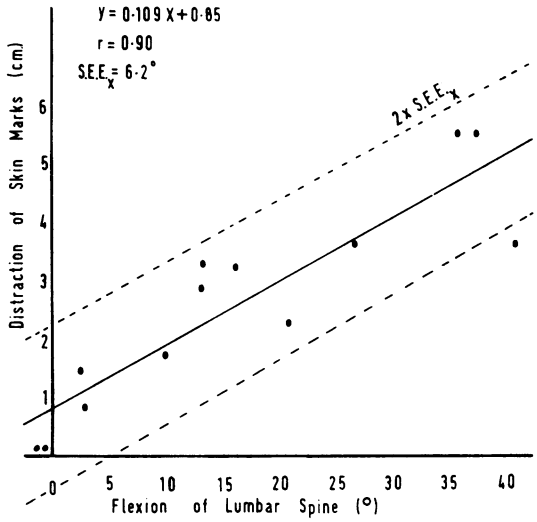

Fig. 5.—Relationship between flexion of lumbar spine and distraction of skin marks 10 cm. apart.

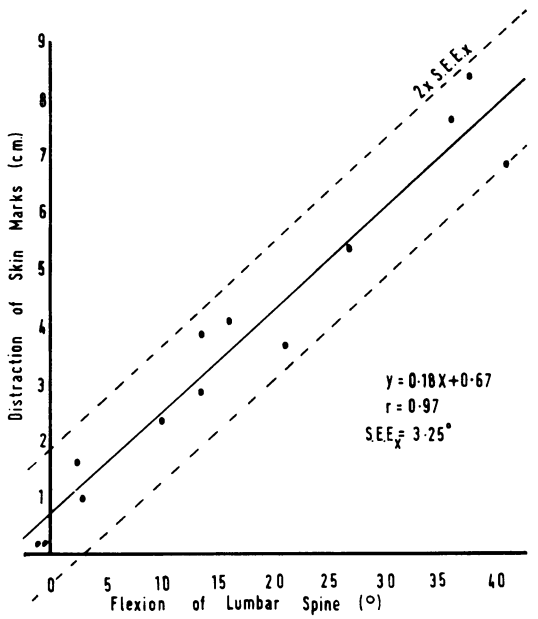

Fig. 6.—Relationship between flexion of lumbar spine and distraction of skin marks 15 cm. apart.

TABLE III
RELATION BETWEEN CLINICAL AND X-RAY IDENTIFICATION OF LUMBOSACRAL JUNCTION

Patient	Error (cm.)	Patient	Error (cm.)
1	+1·9	13	+0·9
2	0·0	14	+1·3
3	0·0	15	+2·1
4	−2·4	16	−1·3
5	−1·6	17	−2·3
6	0·0	18	0·0
7	−1·1	19	0·0
8	+1·2	20	−1·5
9	+2·3	21	−1·6
10	+1·7	22	0·0
11	+1·9	23	−2·0
12	+1·2	24	+1·1

Mean error + 0·075 cm.
Standard deviation 1·47

TABLE IV
INACCURATE IDENTIFICATION OF LUMBOSACRAL JUNCTION AS A CAUSE OF ERROR IN ESTIMATING FLEXION OF LUMBAR SPINE

Distance from Correct Mark	Error (mean ± 2 S.D.) (degrees)	
	Marks 10 cm. apart	Marks 15 cm. apart
2 cm. above	−15·2° to −1·0°	−5·3° to +1·3°
2 cm. below	−4·2° to +13·8°	−3·3° to +3·3°

subjects were marked in the usual manner and a second set of three marks was placed either 2 cm. above or below. Table IV shows the mean error ±2 S.D. resulting from faulty marking. By Schober's method placing the marks 2 cm. too high caused an underestimate of up to 15°, and placing them 2 cm. too low caused an overestimate of up to 14°. With the modified method the errors were very much smaller, 5° and 3° respectively. The test was shown to be independent of hip movement. Figs 3 and 4 are radiographs of a subject with ankylosing spondylitis and a bamboo spine. Having normal hips, this subject was able to bend forward (Fig. 4), but there was no significant change in either the inclination of the spine or the distance between the skin marks.

Differences due to Sex and Age

In view of the above findings the modified 15 cm. marking method was used in the survey and results now reported were obtained by this method. The frequency distribution in the population surveyed is shown in Fig. 7 (opposite). Although this appeared to have the characteristics of a normal frequency distribution, separation of the sexes showed that two normal distributions were contained within this curve (Fig. 8, opposite), the women performing less well than the males. Since the mean age of the females was higher than that of the males, calculations were done to see whether this

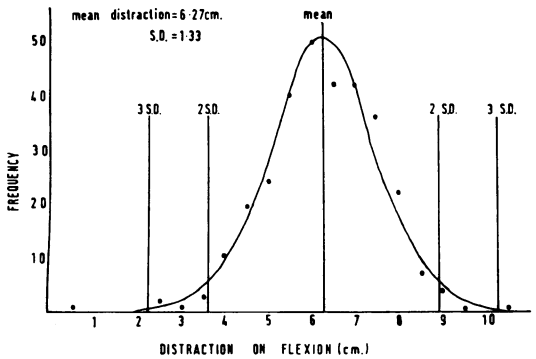

Fig. 7.—Frequency distribution of distraction skin marks on full flexion.

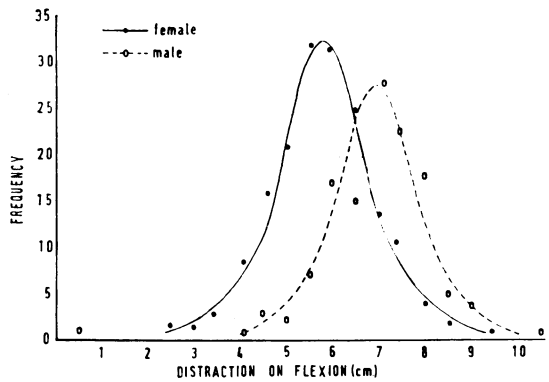

Fig. 8.—Frequency distribution of distraction skin marks on full flexion in both sexes.

explained the sex differences; the histogram in Fig. 9 shows that in all age groups the women did less well.

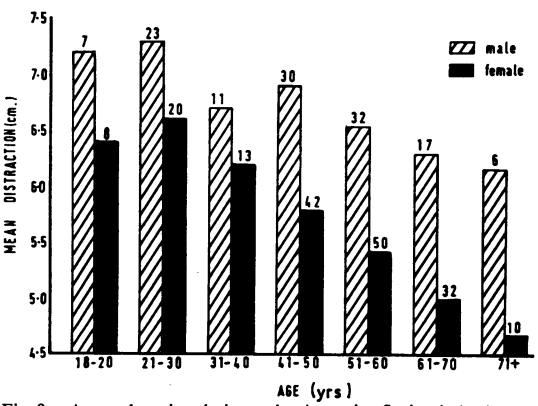

Fig. 9.—Age and sex in relation to lumbar spine flexion in both sexes.

The survey data is presented in Fig. 10 as a regression of distraction related to age. The males showed a significant falling off of performance with increasing age, but this was exhibited to a more

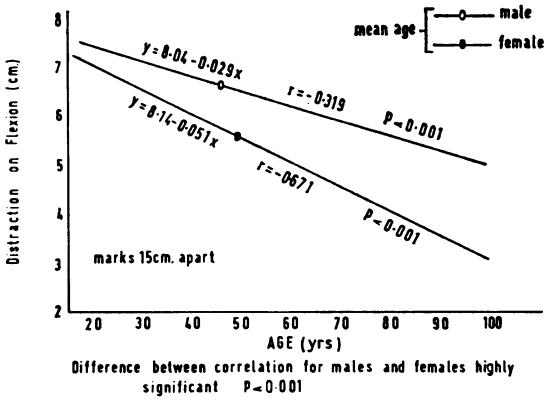

Fig. 10.—Regression lines for predicting distraction from age—both sexes.

striking extent by the females. The differences between the sexes was highly significant. From these regression lines we were able to correct for the effect of age upon performance. Using age-corrected data, the frequency distribution of distraction in males and females is shown in Figs 11 and 12. The curves were not significantly different from a normal frequency distribution.

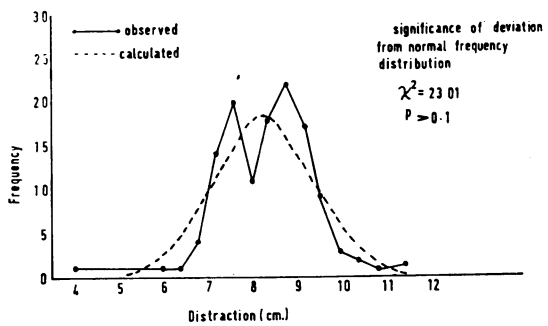

Fig. 11.—Frequency distribution of distraction skin marks on flexion —male corrected for age.

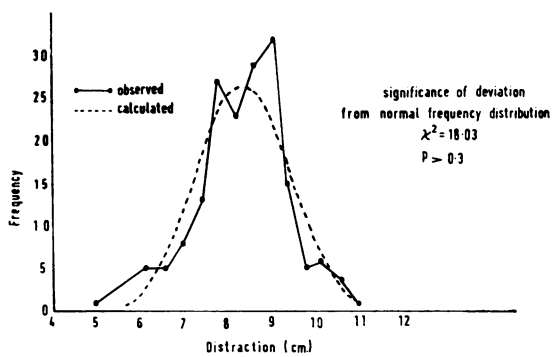

Fig. 12.—Frequency distribution of distraction skin marks on flexion —female corrected for age.

Effect of Height and Weight

Subjects in the sixth decade were specifically examined to observe the effect of height and weight on flexion of the lumbar spine. No significant correlation could be found in 25 men and 47 women (Table V).

TABLE V
CORRELATION BETWEEN HEIGHT, WEIGHT, AND DISTRACTION OF SKIN MARKS 15 CM. APART

Sex	Male (25)	Female (47)
Height	$r = 0{\cdot}14$ $P > 0{\cdot}1$ Not significant	$r = 0{\cdot}17$ $P > 0{\cdot}1$ Not significant
Weight	$r = 0{\cdot}23$ $P > 0{\cdot}1$ Not significant	$r = 0{\cdot}06$ $P > 0{\cdot}1$ Not significant

Ascertainment Value

Using age-corrected data, and taking the sex difference into account, the diagnostic criterion for limitation of motion of the lumbar spine was judged to be fulfilled if the distraction was less than two standard deviations below the mean. Table VI shows those subjects who fulfilled the criterion and indicates the value of the test in ascertaining cases of spondylitis in the population.

TABLE VI
VALUE OF LIMITATION OF FORWARD FLEXION IN ASCERTAINMENT OF ANKYLOSING SPONDYLITIS IN SURVEY

Sex	Male	Female
Total surveyed	147	195
Forward flexion < 2 SD	5	6
False positive	0	5
False negative (Definite ankylosing spondylitis)	6	6
False negative (Classical ankylosing spondylitis	0	0

Of 195 females surveyed, six satisfied the diagnostic criterion for limitation of motion. Five of these, however, were not spondylitics and were therefore false positives. In only one of these (an obese subject) was there any obvious reason.

Of 147 males surveyed, five satisfied the criterion and all of these were spondylitics; there were therefore no false positives.

Six males and six females who satisfied the New York Conference criteria for ankylosing spondylitis (Bennett and Burch, 1967) did not satisfy the criterion for limitation of motion of the lumbar spine. Although listed as false negatives, none had radiological evidence of spinal involvement and were probably examples of disease confined to the sacroiliac joints. No subject with radiological spinal involvement (*i.e.* classical ankylosing spondylitis) failed to satisfy the criterion.

Discussion

Methods for the objective determination of spinal posture and motion have been described. Hart, Robinson, Allchin, and Machagan (1949) used a photographic technique in following a series of patients with ankylosing spondylitis, and Goff and Rose (1964) described an improved version of a spondylometer devised by Thomas (1956). These methods provided information on posture rather than movement. Dunham (1949) invented a spondylometer which measured the motion of the dorsolumbar spine as a whole, and Loebl (1967) developed an inclinometer, which is a pendulum goniometer, that could measure the range of motion of any portion of the spine. Troup, Hood, and Chapman (1968), in an intensive study of the sagittal mobility of the lumbar spine, were unable to find a method suitable for use in clinical practice, but thought that the inclinometer described by Loebl (1967) might be satisfactory if suitably adapted.

For epidemiological purposes a test of spinal movement should be rapid and simple to perform with the least inconvenience to the subject. The only published method we could find that would meet these demands was that of Schober (1937), who measured the distraction of skin marks over the lumbar spine. We noted that both skin marks moved upwards relative to the spinous processes on anterior flexion and that, whereas the skin was poorly tethered to deep structures over the lumbar spine and sacrum, it was relatively well tethered and indeed appeared to stretch from the coccygeal area. This suggested that measuring from a point lower down on the sacrum might offer an improvement and we accordingly took measurements from a skin mark 10 cm. above to another mark 5 cm. below the lumbosacral junction, a distance of 15 cm. in the erect position.

It has been shown radiographically that with both methods there is a linear relationship between the distraction of the skin marks and true forward flexion of the lumbar spine, but the modified method affords a considerable improvement in accuracy.

Clinical identification of the lumbosacral junction is not easy and it has been shown that faulty placing of the skin marks seriously impairs the accuracy of Schober's method, but the modified method is rarely affected. We judged that the overall accuracy of the modified method was adequate for an epidemiological survey.

Results of this survey have shown clearly that in the population studied the ability to flex the back is a graded character dependent on age and sex.

The correction of the data for age and sex reduced the incidence of false positives by eliminating a number of elderly subjects and also reduced the incidence of false negatives by bringing into the abnormal range some young subjects with modest limitation of motion. Although the number of female false positives was high, we were favourably impressed by the performance of the test as an epidemiological tool and judged it to be very satisfactory in the males. There are few objective criteria for the epidemiological diagnosis of ankylosing spondylitis, and the present work suggests that limitation of forward flexion as determined by the method we have outlined may well be a valuable criterion and particularly so since it can be applied objectively. The use of objective methods such as this could achieve a significant increase in the value of population studies.

Summary

An objective test of anterior flexion of the lumbar spine has been used in a population survey. It consisted in observing the distraction of skin marks 15 cm. apart, the upper mark being 10 cm. above the lumbosacral junction and the lower mark 5 cm. below it. This produced a sufficiently accurate measurement of forward flexion of the spine and was considerably more accurate than a method previously described in which marks 10 cm. apart were used. It has been demonstrated that anterior flexion of the lumbar spine is a graded character which is both age and sex dependent. Its value in ascertaining cases of spondylitis in the population assessed.

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Le mesurage des mouvements du dos

Un test objectif de la flexion antérieure de l'épine lombaire a été employé dans un relevé de la population. Il comprenait l'observation de la distraction des marques de la peau séparées de 15 cm., la marque supérieure étant 10 cm. au-dessus de l'articulation lumbo-sacrale et la marque inférieure 5 cm. au-dessous. Cela produisait une mesure suffisamment précise de la flexion antérieure de l'épine dorsale et était beaucoup plus exacte que la méthode décrite précedemment ou des marques séparées de 10 cm. avaient été employées. Il a été démontré que la flexion antérieure de l'épine lombaire est une marque distinctive graduée qui dépend aussi bien de l'âge que du sexe. Sa valeur pour déterminer les cas de spondylite parmi la population a été estimée.

Medida del movimiento de la espalda

En un estudio de población se ha llevado a la práctica una prueba objetiva de la flexión anterior de la región lumbar de la columna vertebral. Consistía en observar la perturbación de marcas en la piel, trazadas a 15 cm. de distancia una de otra, la superior situada a 10 cm. sobre la conexión sacrolumbar y la inferior a cinco centímetros (5 cm.) de ésta. De este modo se obtuvo una medida lo suficientemente exacta de la flexión hacia adelante, de la columna, y resultó considerablemente más exacta que la obtenida por un método descrito previamente, en el cual se emplearon marcas situadas a 10 cm. de distancia entre sí. Se ha demostrado que la flexión anterior de la región lumbar de la espina es una característica graduada que depende tanto de la edad como del sexo. Se ha evaluado su importancia para determinar casos de espondilitis en la población.